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PROGRESS REPORT

INVESTIGATION OF PEROGNATHUS AS AN EXPERIMENTAL ORGANISM FOR RESEARCH IN SPACE BIOLOGY

1 April through 30 June 1966

R. G. Lindberg, Ph.D.
Principal Investigator

PREPARED UNDER CONTRACT NASw-812

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OFFICE OF SPACE SCIENCES
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
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ANATOMY OF THE BRAIN OF <u>PEROGNATHUS LONGIMEMBRIS</u>

Kyllikki Grubel

I. INTRODUCTION

When an animal enters hibernation, certain changes take place in its body functions. The body temperature decreases from normothermic levels, ~ 37°C, down to 0-2°C above the ambient temperature. Oxygen consumption and basal metabolic rate decline. Heat production disappears. Heart rate and respiratory rate decrease. The order in which these things can be observed to take place varies somewhat from species to species, but body temperatures appear to be subservient to the changes in respiration, heart rate or oxygen consumption (Hoffman, 1964). These phenomena are, however, only a result, not the cause, of entry into hibernation. Entry into hibernation is not a simple passive abandonment of temperature regulation, but rather thermoregulatory mechanisms become readjusted at this time. It has been suggested that these changes can be mediated only via the autonomic nervous system. Certain biochemical adjustments or a process of acclimatization takes place in the central nervous system of the prepared hibernator.

As hibernation ensues, certain specific structures or pathways are stimulated to regulate and coordinate the physiological changes as temperatures drop. Throughout hibernation, the peripheral nervous system appears to have an increased sensitivity to certain stimuli. During this period, certain subcortical areas remain functional, ensuring regulation of temperature and of cardiac and respiratory function, while the higher centers become reduced in activity but may maintain a certain minimal function (Hoffman, 1964). The temperature regulation is governed primarily by the thermodetectors of the hypothalamus, and it is possible that some biochemical changes take place in this area of the brain prior to the entry into hibernation. These speculative biochemical changes in the hypothalamus may be the triggering factor for entry into hibernation.

Much more factual information is available on the arousal phase of hibernation than on the entry phase. As arousal commences, the thoracic and brown fat temperature, heart rate, respiratory rate and cardiac output increase rapidly. Peripheral vasoconstriction restricts the increased blood flow mostly to the heart muscle, brown fat, and respiratory muscles and possibly the brain (Bullard and Funkhouser, 1962). The thermogenic brown fat tissue rewarms the blood circulating through it (Smith and Roberts, 1964), and thus aids in the rapid rewarming of heart, brain and respiratory muscles. The important role of brown fat in arousal of hibernators was shown by Smith and Hock in marmots (1963) and Smalley and Dryer in bats (1963). It appears, though, that the activation of brown fat tissue is under nervous control (Kauppinen, Bullard and Smith, 1964), and that the thermoregulatory centers of hypothalamus trigger the spontaneous arousals. It is most likely that some biochemical changes take place in the hypothalamus during hibernation and that these changes would cause the initiation of arousal.

This report describes the anatomy of the brain of P. longimembris. The task was undertaken to provide orientation in the internal structures of the brain and to establish the feasibility of studying the neurological basis of entry into and arousal from hibernation using P. longimembris as an experimental animal.

II. MATERIALS AND METHODS

Four adult mice of species Perognathus longimembris were lightly anesthetized with ether and then killed by decapitation. The brains of the animals were extirpated, cut crosswise in two parts and placed in toluidine blue fixative and stain (Davenport, 1960). After about one week's fixation period, the brains were frozen and sectioned in 50 μ thick slices. From the four sectioned brains, the best slides were chosen to compose one representative brain of P. longimembris. From this representative brain, photographs were taken from sections at 1 mm intervals. The location of each section in question is marked as a vertical line in the drawing of a medial sagittal section of a brain (fig. 1). The scale of Figure 1 is 15:1, and the scale of the cross section photographs and line drawings (figs. 2-8) is 28:1.

The small size of the pocket mouse precluded the use of standard stereotaxic apparatus to establish coordinates. The anatomical structures of the brain were identified, and the nomenclature used is that found in König and Klippel (1963).

III. RESULTS

The results are presented in the following seven photographs and corresponding line drawings of the cross sections of the brain of P. *longimembris* (figs. 2-8).

LEGENDS TO THE FIGURES

Figure 1. Drawing of a medial sagittal section of the brain of P. *longimembris*. Scale 15:1. Vertical lines 1 - 7 mark the corresponding cross section 1 - 7, (figs. 2 - 8).

Figures 2a - 8a. Photographs of cross sections of the brain of P. *longimembris*. Scale 28:1.

Figures 2b - 8b. Line drawings of cross sections of the brain of P. *longimembris*. Scale 28:1.

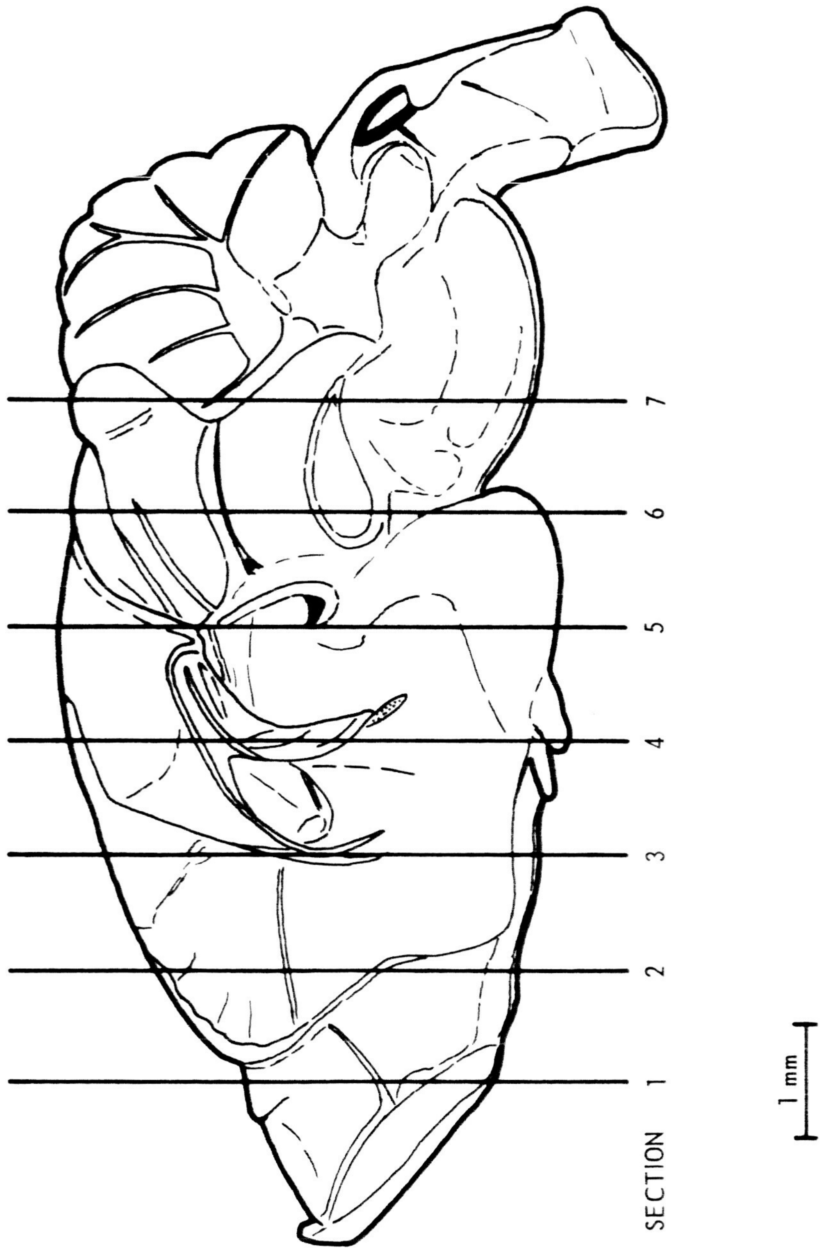


FIGURE 1

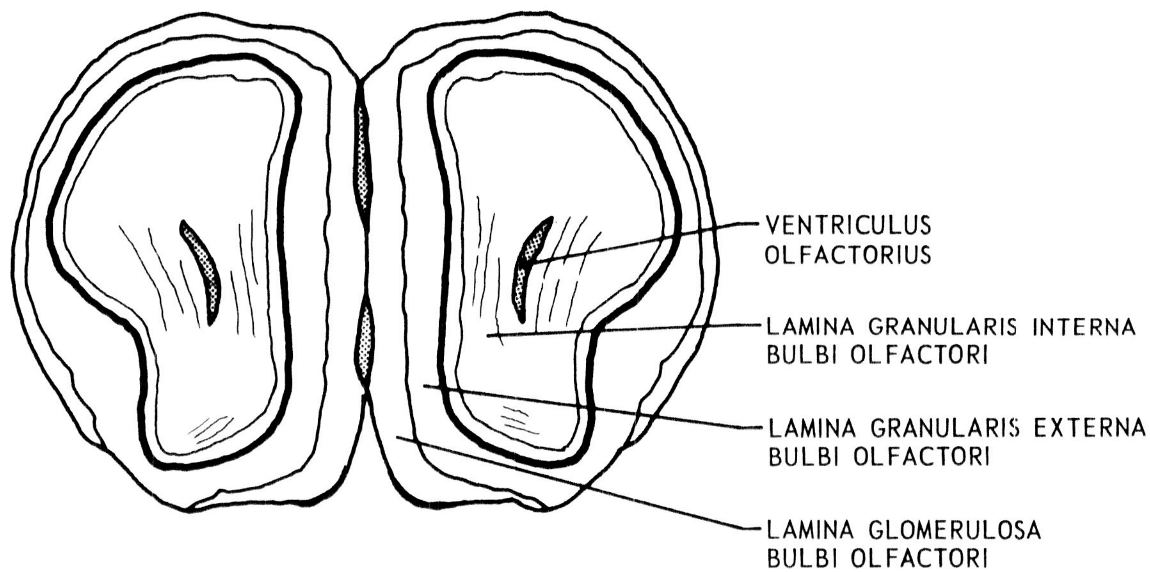
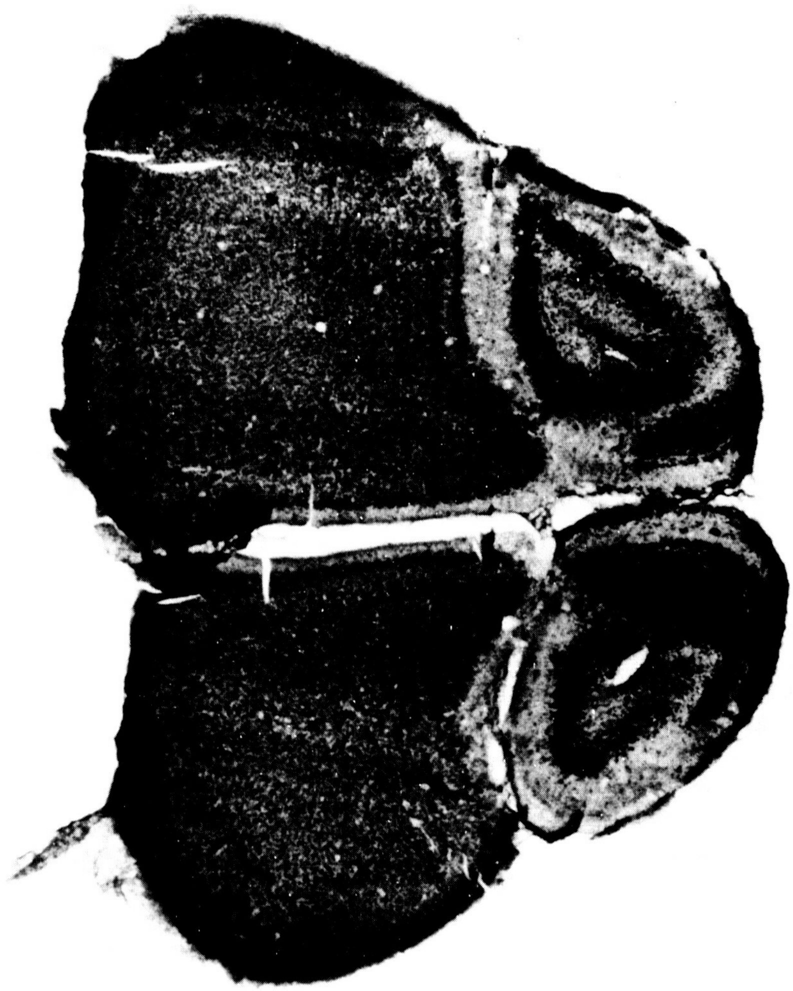

VENTRICULUS OLFACTORIUS
LAMINA GRANULARIS INTERNA BULBI OLFACTORI
LAMINA GRANULARIS EXTERNA BULBI OLFACTORI
LAMINA GLOMERULOSA BULBI OLFACTORI

FIGURE 2



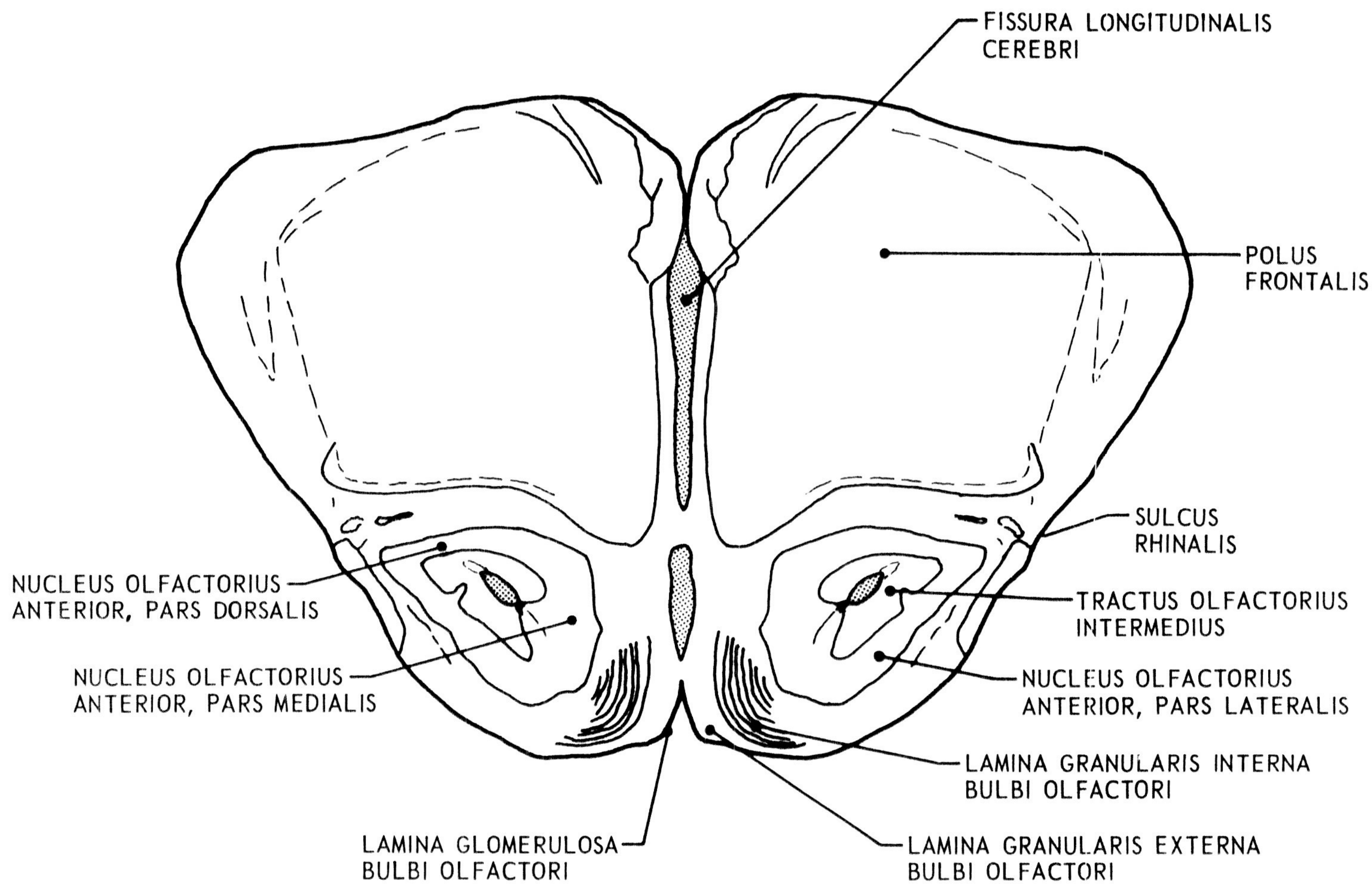
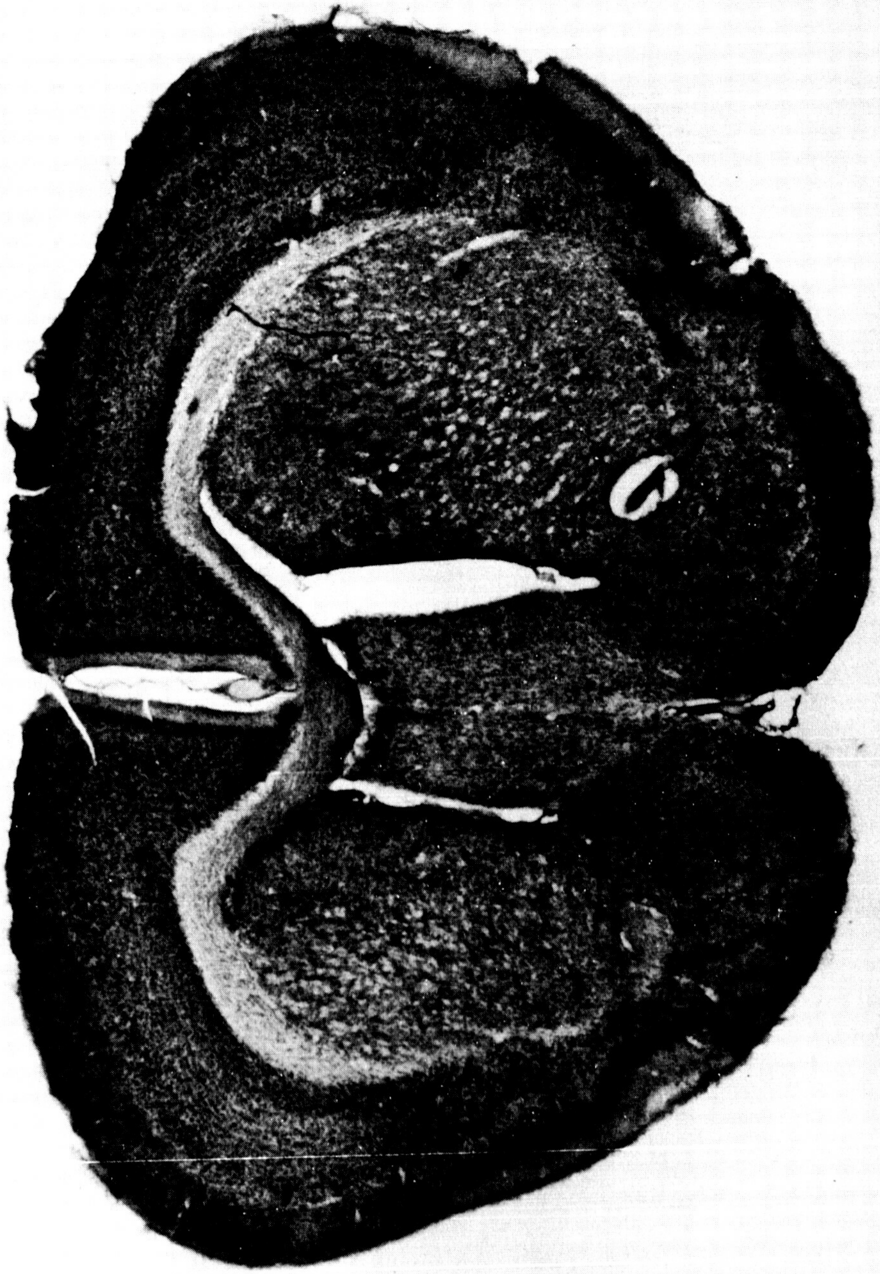

FISSURA LONGITUDINALIS CEREBRI
POLUS FRONTALIS
SULCUS RHINALIS
NUCLEUS OLFACTORIUS ANTERIOR, PARS DORSALIS
TRACTUS OLFACTORIUS INTERMEDIUS
NUCLEUS OLFACTORIUS ANTERIOR, PARS MEDIALIS
NUCLEUS OLFACTORIUS ANTERIOR, PARS LATERALIS
LAMINA GRANULARIS INTERNA BULBI OLFACTORI
LAMINA GLOMERULOSA BULBI OLFACTORI
LAMINA GRANULARIS EXTERNA BULBI OLFACTORI

FIGURE 3



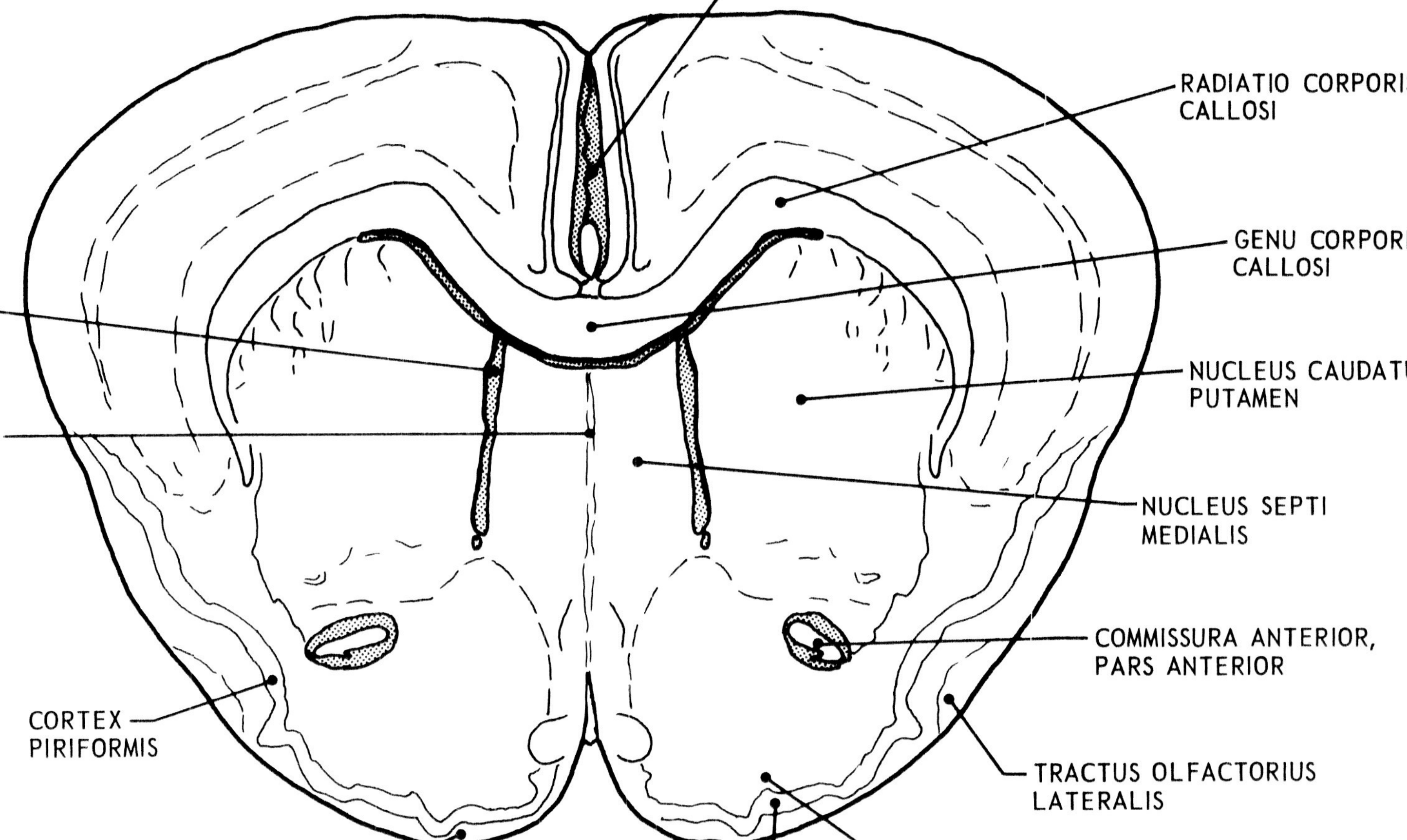
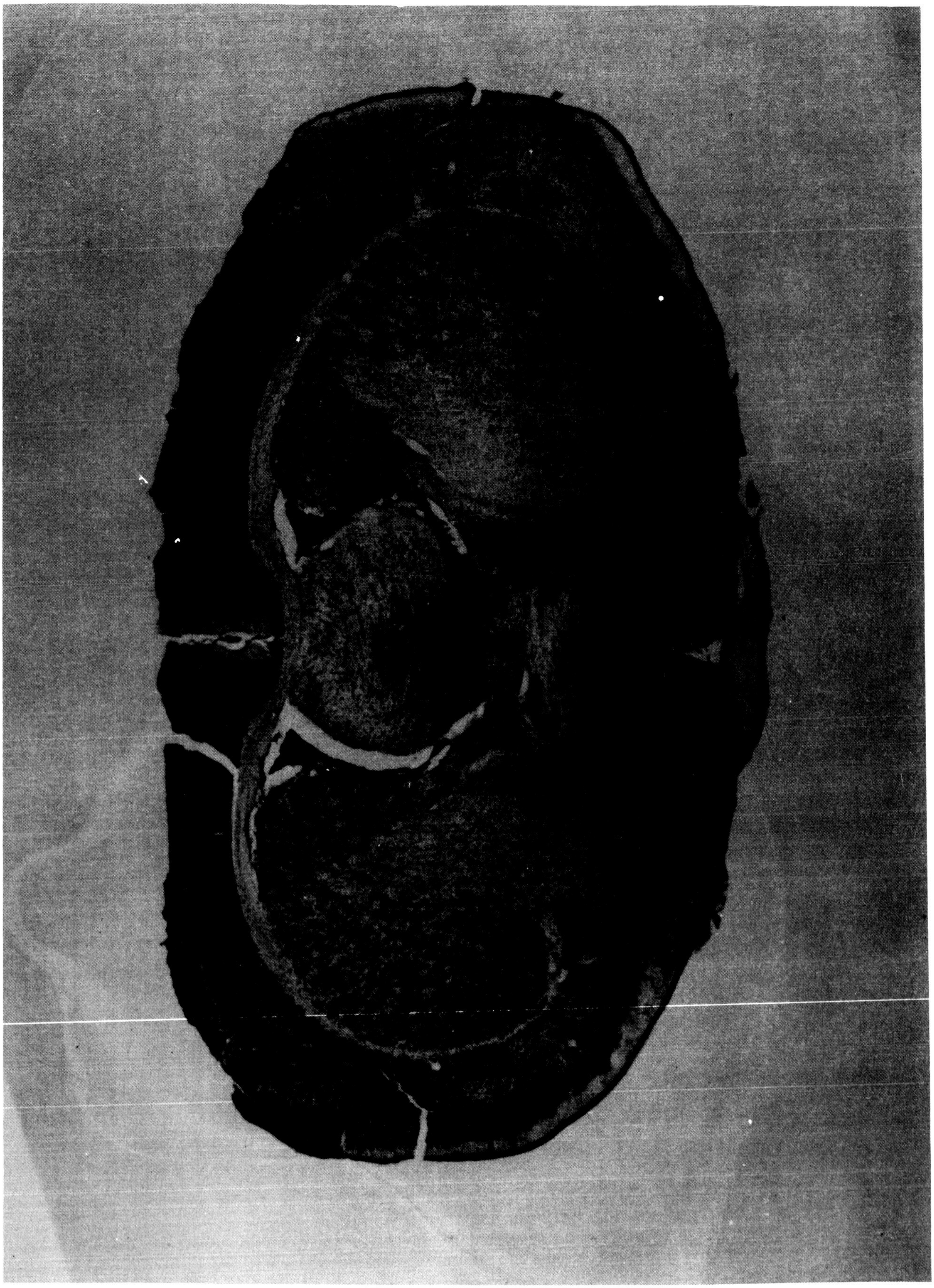

FISSURA LONGITUDINALIS CEREBRI
RADIATIO CORPORIS CALLOSI
GENU CORPORIS CALLOSI
VENTRICULUS LATERALIS
NUCLEUS CAUDATUS PUTAMEN
NUCLEUS SEPTI LATERALIS
NUCLEUS SEPTI MEDIALIS
COMMISSURA ANTERIOR, PARS ANTERIOR
CORTEX PIRIFORMIS
TRACTUS OLFACTORIUS LATERALIS
TUBERCULUM OLFACTORIUM, PARS CORTICALIS, LAMINA PLEXIFORMIS
TUBERCULUM OLFACTORIUM, PARS CORTICALIS, LAMINA PYRAMIDALIS
TUBERCULUM OLFACTORIUM, PARS INTERNA, LAMINA POLYFORMICA

FIGURE 4



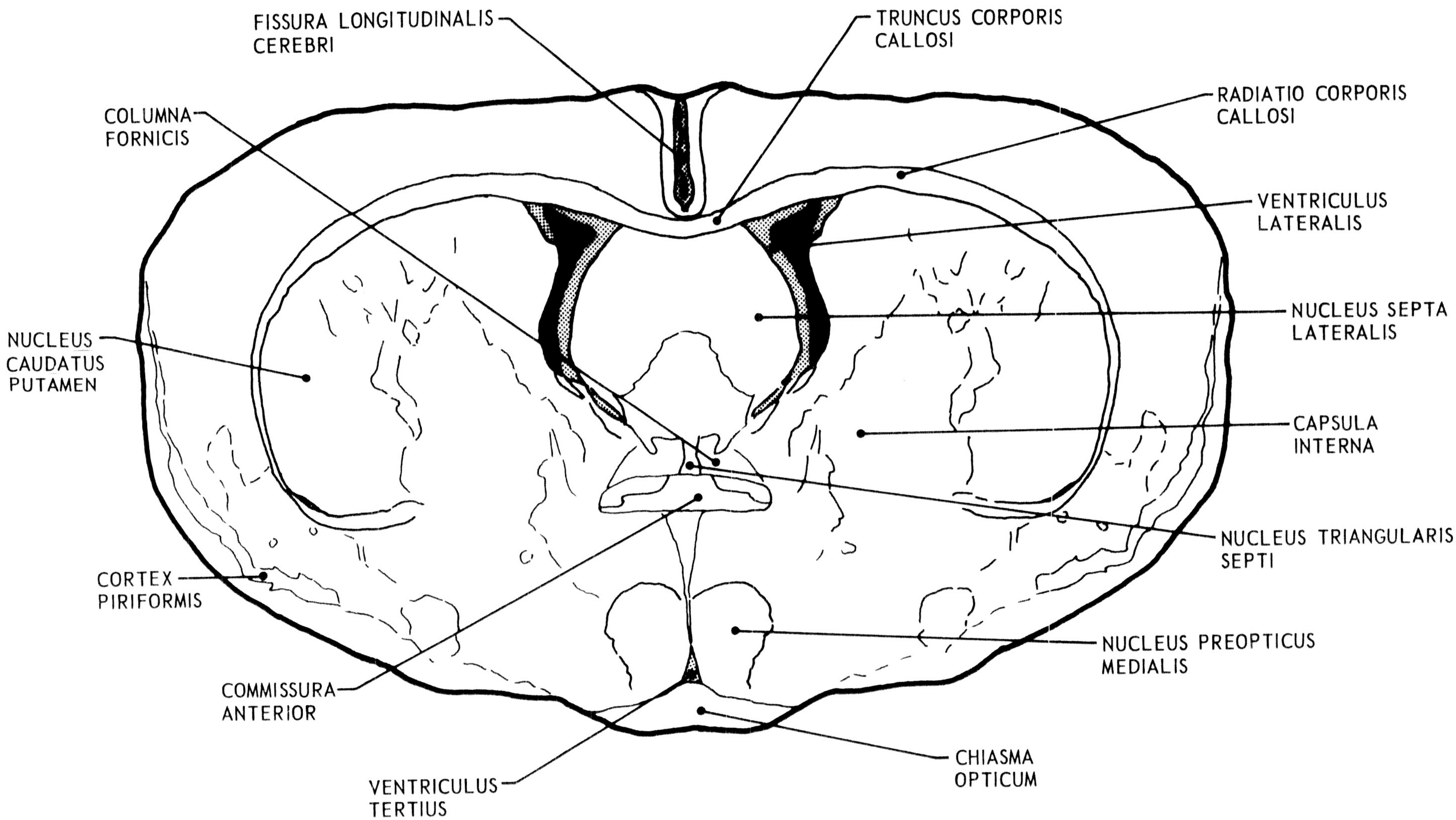

FISSURA LONGITUDINALIS CEREBRI
TRUNCUS CORPORIS CALLOSI
RADIATIO CORPORIS CALLOSI
COLUMNA FORNICIS
VENTRICULUS LATERALIS
NUCLEUS SEPTA LATERALIS
NUCLEUS CAUDATUS PUTAMEN
CAPSULA INTERNA
NUCLEUS TRIANGULARIS SEPTI
CORTEX PIRIFORMIS
NUCLEUS PREOPTICUS MEDIALIS
COMMISSURA ANTERIOR
CHIASMA OPTICUM
VENTRICULUS TERTIUS

FIGURE 5

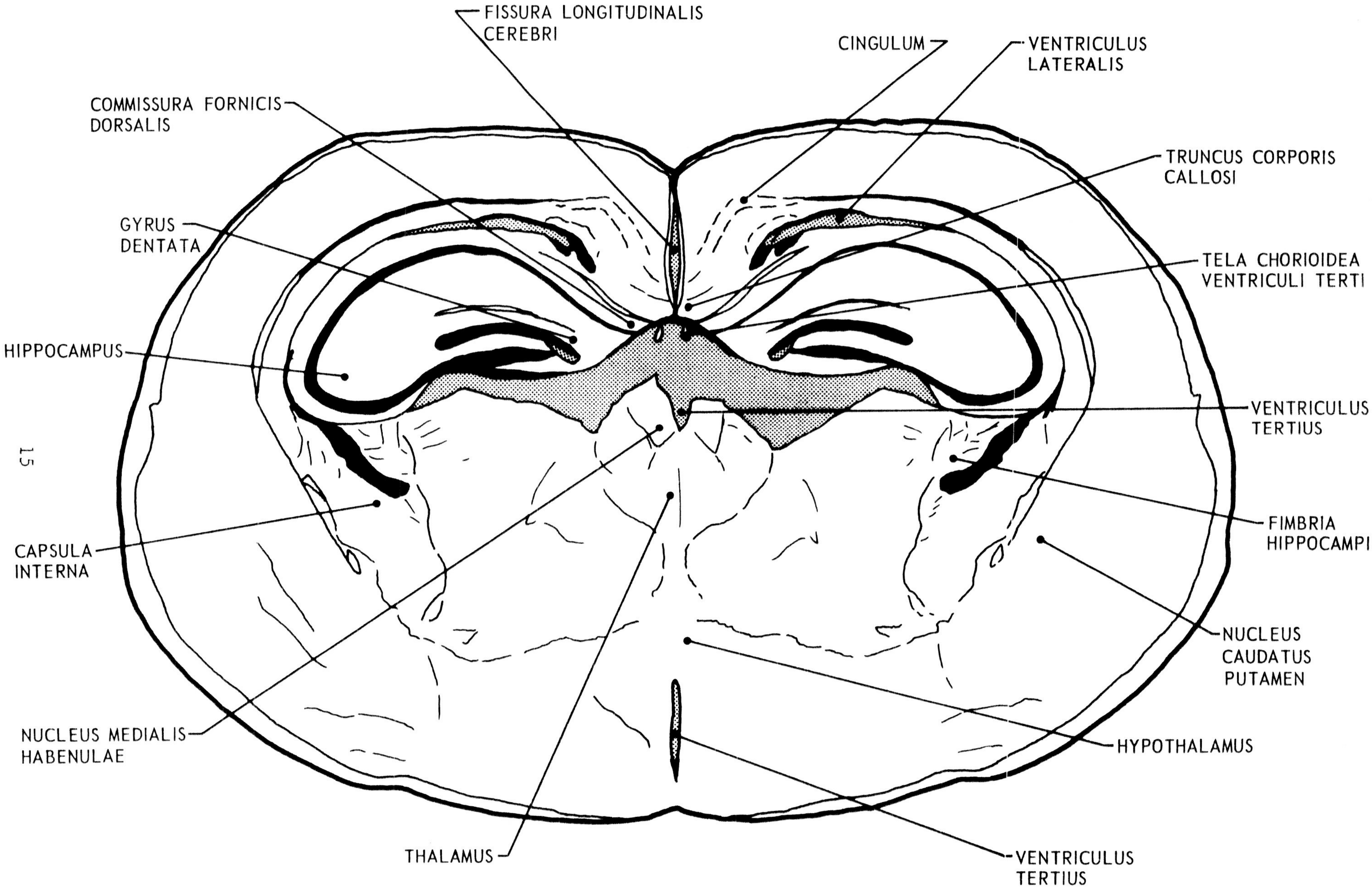

FISSURA LONGITUDINALIS CEREBRI
CINGULUM
VENTRICULUS LATERALIS
COMMISSURA FORNICIS DORSALIS
TRUNCUS CORPORIS CALLOSI
GYRUS DENTATA
TELA CHORIOIDEA VENTRICULI TERTI
HIPPOCAMPUS
VENTRICULUS TERTIUS
CAPSULA INTERNA
FIMBRIA HIPPOCAMPI
NUCLEUS CAUDATUS PUTAMEN
NUCLEUS MEDIALIS HABENULAE
HYPOTHALAMUS
THALAMUS
VENTRICULUS TERTIUS

FIGURE 6

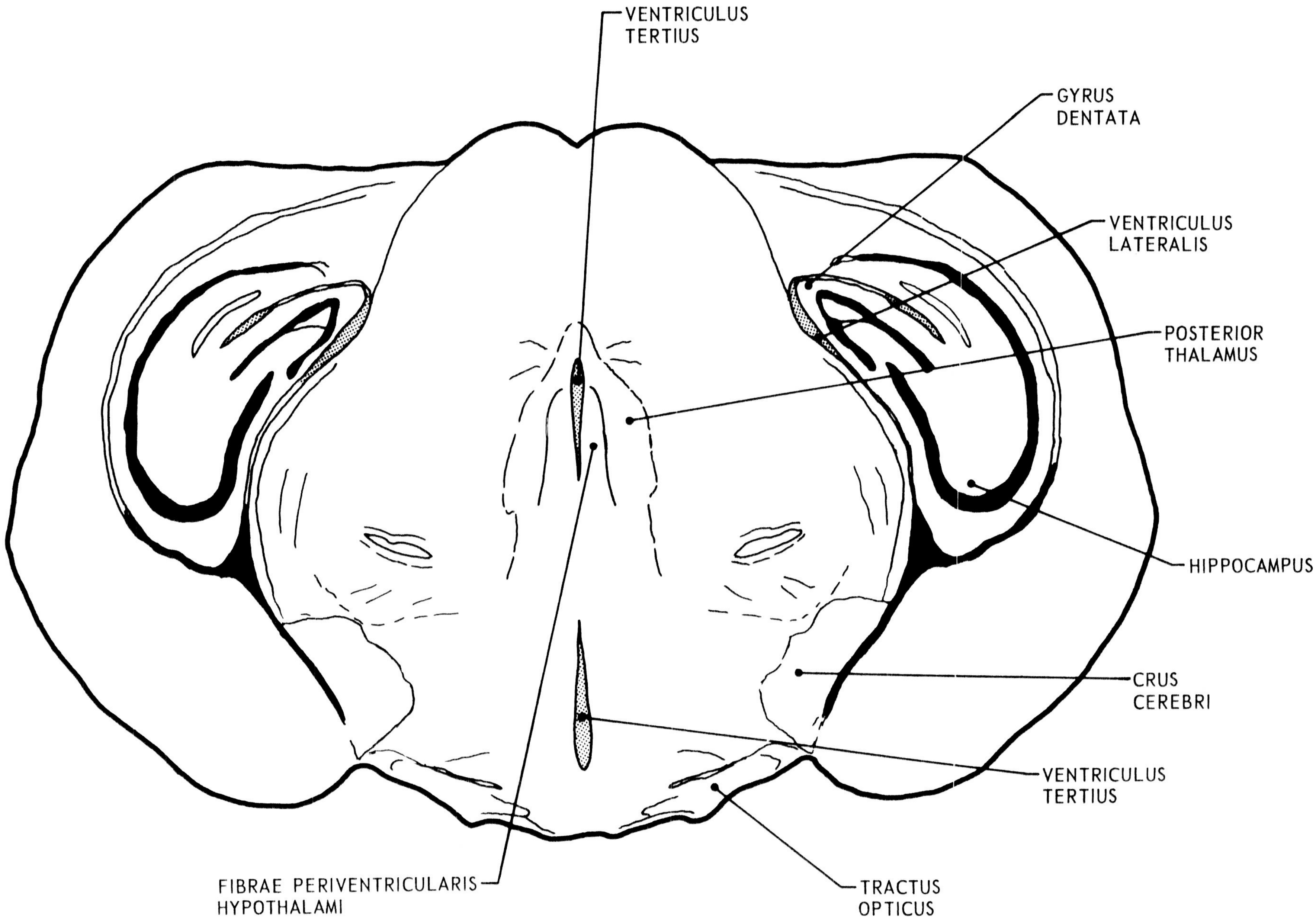
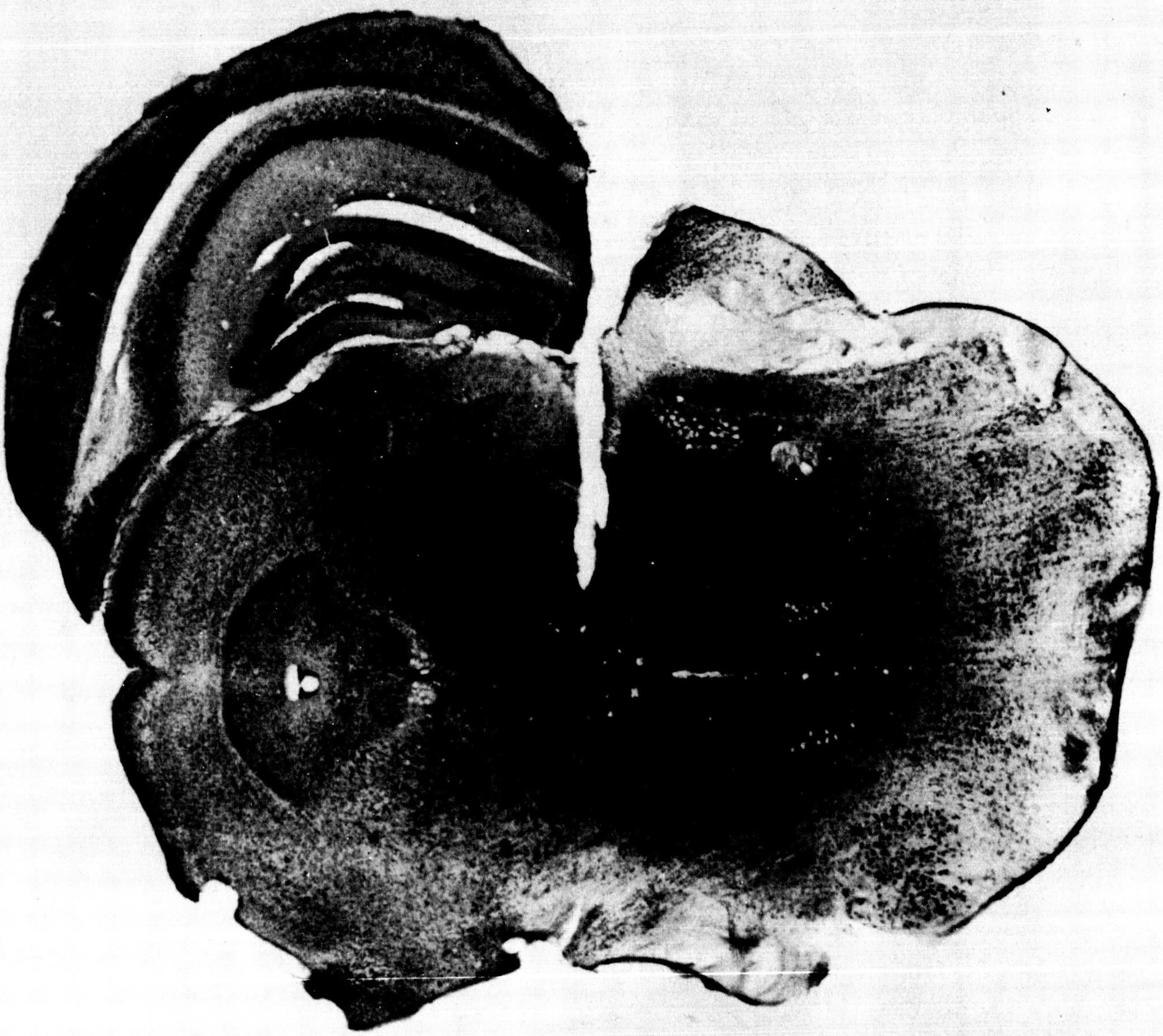

VENTRICULUS TERTIUS
GYRUS DENTATA
VENTRICULUS LATERALIS
POSTERIOR THALAMUS
HIPPOCAMPUS
CRUS CEREBRI
VENTRICULUS TERTIUS
TRACTUS OPTICUS
FIBRAE PERIVENTRICULARIS HYPOTHALAMI

FIGURE 7



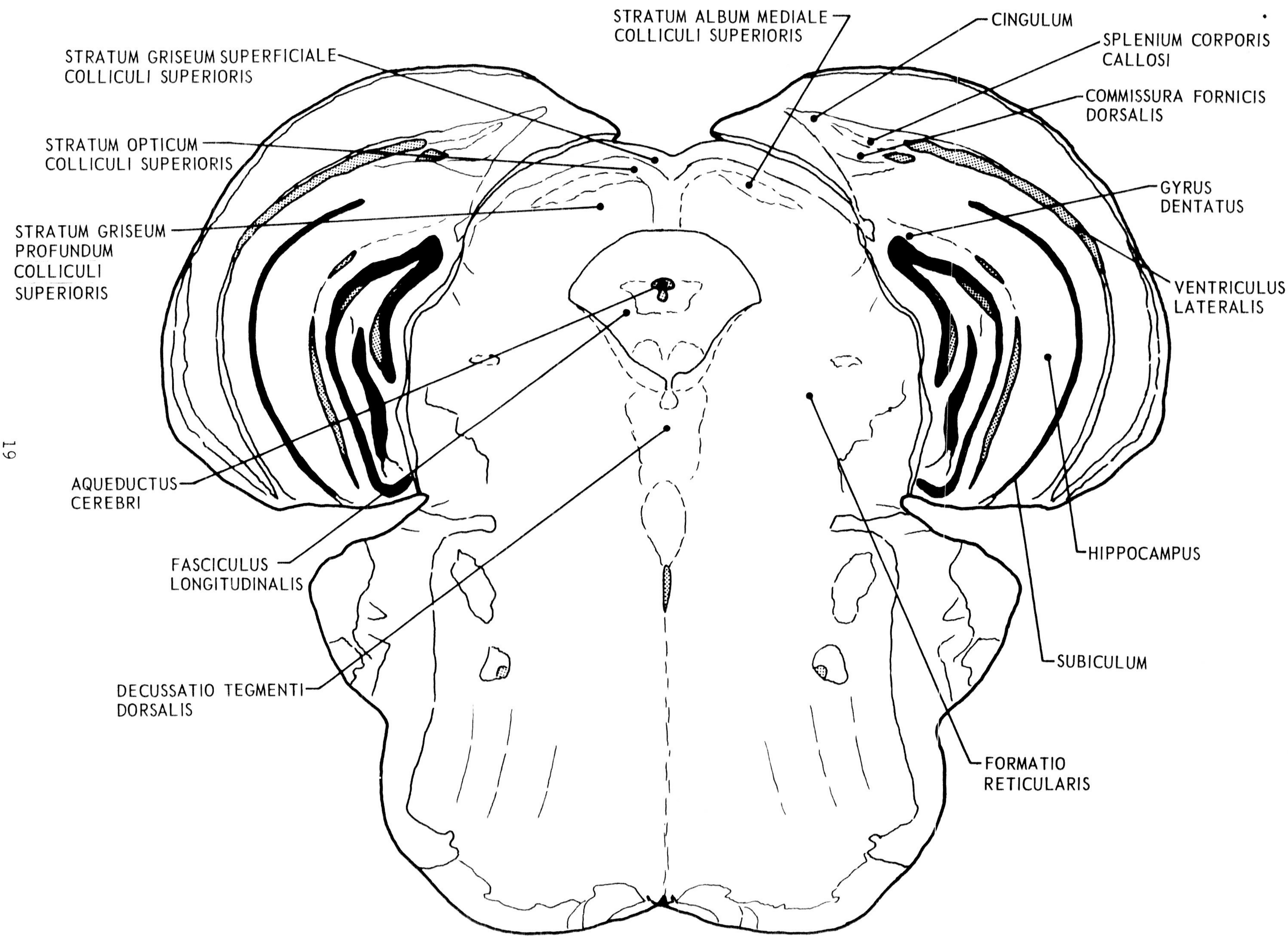

STRATUM ALBUM MEDIALE COLLICULI SUPERIORIS
CINGULUM
SPLENIUM CORPORIS CALLOSI
STRATUM GRISEUM SUPERFICIALE COLLICULI SUPERIORIS
COMMISSURA FORNICIS DORSALIS
STRATUM OPTICUM COLLICULI SUPERIORIS
GYRUS DENTATUS
STRATUM GRISEUM PROFUNDUM COLLICULI SUPERIORIS
VENTRICULUS LATERALIS
AQUEDUCTUS CEREBRI
HIPPOCAMPUS
FASCICULUS LONGITUDINALIS
SUBICULUM
DECUSSATIO TEGMENTI DORSALIS
FORMATIO RETICULARIS

FIGURE 8

IV. SUMMARY AND CONCLUSION

The anatomy of the brain of P. longimembris does not differ markedly from that of the albino rat. However, the small size of the animal and its brain dictates the need for development of special handling techniques and equipment if the species is to be used for neurophysiological research.

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